

CLAIMS

1. A device for lighting a high-pressure discharge lamp, comprising:

5 a DC power supply:

a first switching element having one terminal connected to the high-pressure side of the DC power supply;

a second switching element having one terminal connected to the low-voltage side of the DC power supply;

10 a third switching element having one terminal connected to the high-pressure side of the DC power supply;

a fourth switching element having one terminal connected to the low-voltage side of the DC power supply;

15 a first inductor having one terminal connected to the other terminals of the first and second switching elements, and the other terminal connected to one terminal of the high-pressure discharge lamp;

20 a first capacitor connected between an intermediate section of a winding of the first inductor and the low-voltage side of the DC power supply, and composing a first series resonant circuit together with the first inductor;

a second capacitor having one terminal connected to the one terminal of the first inductor, and the other terminal connected to the other terminal of the high-pressure discharge lamp;

25 a second inductor having one terminal connected to the other terminals of the third and fourth switching elements, and the other terminal connected to the other terminal of the second capacitor; and

30 a control circuit for controlling turning on and off of the first to fourth switching elements,

wherein, before the high-pressure discharge lamp is started up, the control circuit performs control in a first control mode which alternately switches between a state in which the first and fourth switching elements are on and the second and third switching elements are off and a state in which the first and fourth

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switching elements are off and the second and third switching elements are on, at a predetermined switching frequency, and

5 in the first control mode, the first series resonant circuit is resonated at a frequency of integral times the switching frequency to generate a high voltage for starting up the high-pressure discharge lamp.

10 2. The high-pressure discharge lamp lighting device according to claim 1, wherein, after the high-pressure discharge lamp is started up, the control circuit performs control in a second control mode which alternately switches at a low-frequency between,

15 an operation for alternately switching at a high-frequency between a state in which the first and fourth switching elements are simultaneously on, and a state in which at least one of the first and fourth switching elements is off and

20 an operation for alternately switching at a high-frequency between a state in which the second and third switching elements are simultaneously on and a state in which at least one of the second and third switching elements is off.

3. A device for lighting a high-pressure discharge lamp, comprising:

a DC power supply:

25 a first switching element having one terminal connected to the high-pressure side of the DC power supply;

a second switching element having one terminal connected to the low-voltage side of the DC power supply;

30 a first inductor having one terminal connected to the other terminals of the first and second switching elements, and the other terminal connected to one terminal of a high-pressure discharge lamp;

35 a first capacitor connected between an intermediate section of a winding of the first inductor and the low-voltage side of the DC power supply and composing a first series resonant circuit together with the first inductor;

a second capacitor having one terminal connected to the one terminal of the first inductor, and the other terminal connected to the other terminal of the high-pressure discharge lamp;

5 a second inductor having one terminal connected to the other terminal of the second capacitor;

a third capacitor connected between the high-pressure side of the DC power supply and the other terminal of the second inductor,

10 a fourth capacitor connected between the low-voltage side of the DC power supply and the other terminal of the second inductor; and

a control circuit for controlling turning on and off of the first and second switching elements,

15 wherein before the high-pressure discharge lamp is started up, the control circuit performs control in a first control mode which alternately switches between a state in which the first switching element is on and the second switching element is off and a state in which the first switching element is off and the second switching element is on, at a predetermined switching frequency, and

20 in the first control mode, the first series resonant circuit is resonated at a frequency of integral times the switching frequency to generate a high voltage for starting up the high-pressure discharge lamp.

25 4. The high-pressure discharge lamp lighting device according to claim 3, wherein after the high-pressure discharge lamp is started up, the control circuit performs control in a second control mode which alternately switches at a first low-frequency between an operation for controlling turning on and off of the first switching element at a high-frequency and an operation for controlling turning on and off the second switching element at a high-frequency.

35 5. The high-pressure discharge lamp lighting device according to claim 1 or 3, wherein the switching frequency is lower

than a resonant frequency of the first series resonant circuit and higher than a resonant frequency of a second series resonant circuit including the second inductor and the second capacitor.

5 6. The high-pressure discharge lamp lighting device according to claim 1 or 3, wherein, in the first control mode, a frequency of a high voltage generated by the first series resonant circuit is $(2n+1)$ (n is a natural number) times the switching frequency.

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7. The high-pressure discharge lamp lighting device according to claim 1 or 3, wherein the switching frequency is higher than two times the resonant frequency of a second series resonant circuit including the second inductor and the second capacitor.

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8. The high-pressure discharge lamp lighting device according to claim 1 or 3, wherein the control circuit varies the switching frequency depending on time in the first control mode.

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9. The high-pressure discharge lamp lighting device according to claim 8, wherein a variable range of the switching frequency is set such that the resonant frequency of the first series resonant circuit is included in a range from an integral multiple of the lower limit of the variable range to an integral multiple of the upper limit of the variable range.

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10. The high-pressure discharge lamp lighting device according to claim 9, wherein the frequency corresponding to the integral multiple of the switching frequency is $(2N + 1)$ times (n is a natural number) the switching frequency.

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11. The high-pressure discharge lamp lighting device according to claim 10, wherein the frequency corresponding to the integral multiple of the switching frequency is three times the switching frequency.

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12. The high-pressure discharge lamp lighting device according to claim 8, wherein the control circuit has a digital arithmetic processing circuit, and the switching frequency is
5 discretely varied by the digital arithmetic processing circuit.

13. The high-pressure discharge lamp lighting device according to claim 8, wherein the control circuit has an analog arithmetic processing circuit, and the switching frequency is
10 continuously varied by the analog arithmetic processing circuit.

14. The high-pressure discharge lamp lighting device according to claim 1 or 3, wherein the first and second switching elements are PWM-controlled at a duty ratio of about 50%, and the
15 first and second switching elements alternately repeat on and off-operations at equal time intervals.

15. The high-pressure discharge lamp lighting device according to claim 1 or 3, wherein the first inductor has a
20 transformer structure provided with a primary winding and a secondary winding, one terminal of the primary winding is connected to one terminal of the secondary winding, and the first capacitor is connected to the connection point between the primary winding and the secondary winding.

25 16. The high-pressure discharge lamp lighting device according to claim 1 or 3, wherein the first inductor has a transformer structure provided with a primary winding and a secondary winding, and a ratio of the numbers of turns of the
30 primary winding and the secondary winding is given by $1:N$ ($N > 1$).

17. The high-pressure discharge lamp lighting device according to claim 1 or 3, wherein the first inductor has a transformer structure provided with a primary winding and a
35 secondary winding, the primary winding is constituted by a litz wire,

and the secondary winding is constituted by a single wire.

18. The high-pressure discharge lamp lighting device according to claim 1 or 3, further comprising

5 a start up detector operable to detect the start up of the high-pressure discharge lamp,

wherein, when the start up detector detects the start up of the high-pressure discharge lamp, the control circuit performs control in a third control mode which alternately switches at a low-
10 frequency between,

an operation for switching at a high-frequency among, a state in which the first and fourth switching elements are simultaneously on, a state in which one of the first and fourth switching elements is off, and a state in which both the first and
15 fourth switching elements are off, sequentially in the order, and

an operation for switching at a high-frequency among, a state in which the second and third switching elements are simultaneously on, a state in which one of the second and third switching elements is off, and a state in which both the second and
20 third switching elements are off, sequentially in the order.

19. The high-pressure discharge lamp lighting device according to claim 18, wherein a switching operation from the first control mode to the third control mode is conducted when a
25 predetermined period of time passes after the start up of the high-pressure discharge lamp is detected.

20. The high-pressure discharge lamp lighting device according to claim 18, wherein the switching frequency of the first
30 control mode is higher than a high-frequency by which the switching elements are switched in the third control mode.

21. The high-pressure discharge lamp lighting device according to claim 1 or 3, further comprising a main circuit board
35 and an auxiliary circuit board on which the electronic parts

comprised in the high-pressure discharge lamp lighting device can be mounted,

wherein terminal pads for soldering connection to the main circuit board are formed on both the upper and lower surfaces of the lower part of the auxiliary circuit board,

a slit in which the auxiliary circuit board is inserted and which supports the auxiliary circuit board is formed in the main circuit board, and

the slit has a portion which has a first width and is electrically connected to the auxiliary circuit board and a portion which has a second width which is almost equal to or smaller than the thickness of the auxiliary circuit board, and the first width is larger than the second width.

22. The high-pressure discharge lamp lighting device according to claim 21, wherein, projecting portions which can be in contact with the surface of the main circuit board when the auxiliary circuit board is inserted into the main circuit board is formed in a space between the terminal pads formed on the lower part of the auxiliary circuit board and an electronic parts mounted on the auxiliary circuit board, and on both the upper and lower surfaces of the auxiliary circuit board.

23. The high-pressure discharge lamp lighting device according to claim 22, wherein the projecting portion comprises a rod almost perpendicularly penetrates a hole running from the upper surface to the lower surface in the auxiliary circuit board.

24. The high-pressure discharge lamp lighting device according to claim 22, wherein the projecting portion comprises an electronic part arranged between the other electronic parts mounted on both the upper and lower surfaces of the auxiliary circuit board and the terminal pads.

25. The high-pressure discharge lamp lighting device

according to claim 22, wherein the projecting portion comprises a U-shaped jig fixed to at least one end in the longitudinal direction of the auxiliary circuit board such that the jig straddles both the upper and lower surfaces of the auxiliary circuit board.

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26. The high-pressure discharge lamp lighting device according to claim 21, wherein the terminal pads are formed at symmetrical positions on the upper and lower surfaces of the auxiliary circuit board.

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27. The high-pressure discharge lamp lighting device according to claim 26, wherein the terminal pads formed at the symmetrical positions of the upper and lower surfaces of the lower part of the auxiliary circuit board have electrically the same potential.

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28. The high-pressure discharge lamp lighting device according to claim 21, further comprising a variable resistor for output control connected to the high-pressure discharge lamp in series and mounted on the auxiliary circuit board,

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wherein, when the auxiliary circuit board is inserted into the main circuit board, the output control variable resistor is positioned at a position closer to the surface of the main circuit board than an intermediate point of a height of the highest part of the auxiliary circuit board with reference to the surface of the main circuit board.

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29. The high-pressure discharge lamp lighting device according to claim 21, wherein an electric wiring pattern formed on the auxiliary circuit board includes a part to which a low voltage is applied and a part to which a high voltage is applied, and the part to which the high voltage is applied is formed on the peripheral portion of the auxiliary circuit board.

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30. The high-pressure discharge lamp lighting device

according to claim 21, wherein the auxiliary circuit board is arranged near the peripheral portion of the main circuit board.

- 5 31. A light fixture comprising a high-pressure discharge lamp lighting device according to claim 1 or 3, and a high-pressure discharge lamp lighted by the high-pressure discharge lamp lighting device.